DEVELOPMENT OF A REGIONAL COASTAL AND OPEN OCEAN FORECAST SYSTEM

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LONG-TERM GOALS

The long term goal is to construct, verify and demonstrate an efficient system for the realistic, accurate and efficient estimation of oceanic fields which can be deployed rapidly in any region of the world ocean: the coastal and shelf ocean, across the shelfbreak and the open ocean.

OBJECTIVES

The objectives of this research are: i) to continue the development of a relocatable, portable and efficient ocean prediction system for realtime forecasting and interdisciplinary research; ii) to demonstrate and validate HOPS in realtime exercises at sea and on land; iii) to implement regional forecast system methodologies; and, iv) to share software with the modeling and operational community.

APPROACH

The approach to software implementation within the Harvard Ocean Prediction System allows simple and flexible inter-module flow of information and the addition of models and procedures developed in-house or elsewhere. Standard data management procedures, data formats, generic data assimilation schemes amenable for use in diverse models are required. The approach to data assimilation emphasizes treatment of the data before assimilation via Structured Data Models (e.g. feature models and EOFs) which are used to represent synoptic structures. The approach to regional forecast system development involves: an Exploratory phase in which dominant scales, processes and interactions are identified; a Dynamical phase which establishes the circulation structures, the processes of synoptic evolution and events, and calibrates the regional system; and, a Predictive phase involving forecast experiments to verify the regional forecast system.

WORK COMPLETED

Completed software improvements to HOPS include: the inclusion of programs for data management and data pre-treatment; forward compatibility of the output with newer versions of netCDF; improved fidelity, targetability and speed of the conditioning of topographic slopes; a new algorithm to aid the speed of gridding data; the inclusion of OSSE software for sampling PE model fields on the fly; and, improved writing and visualizing of PE model diagnostic fields (term balance fields). The portability of HOPS continues to improve through the feedback from external users.

Real time operations:

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1. PRIMER (Western North Atlantic) - HOPS was utilized in real-time, at-sea and assimilated SEASOAR data as acquired as a demonstration of concept for adaptive sampling (adaptive sampling was not possible due to bad weather); HOPS was used in an OSSE mode prior to at-sea operations to study potential variations in the position of an eddy in the research area;

2. P^2S^3 (Eastern North Atlantic) - during the "Plankton Patchiness Studies by Ship and Satellite" cruise, HOPS was used to help study the relationship between physical conditions and biological mesoscale patchiness during the Spring Bloom. Harvard scientists conducted real-time shipboard nowcast and forecast model simulations, including physical and biological data assimilation and using meteorological forecast information from FNMOC; in addition, model simulations at sea and on land at Harvard were simultaneously carried out and intercompared for the first time, with direct ship-to-shore and shore-to-ship transfer of data and model results;

3. MASSBAY (Massachusetts Bay) - HOPS was set-up and transferred to the MIT AUV Laboratory. OSSEs were performed, in collaboration with the MIT AUV Laboratory, in anticipation of a summer experiment. Although the experiment was eventually postponed, the completed OSSEs provided important information regarding dynamical responses in the region;

4. RAPID RESPONSE (RR97), DYNAMIC MIX, DAMSEL FAIR - HOPS was utilized during the military oceanography survey Rapid Response and the military operations Dynamic Mix and Damsel Fair to provide ongoing (August - October) operational forecasts and products (temperature profiles, currents, etc.) and in the adaptive sampling design of multiple AXBT flights. A Rapid Environmental Assessment (REA) OSSE has been completed which demonstrates the effects of assimilating various types and quantities of data.

RESULTS

As noted above, HOPS was utilized, demonstrated and validated for several regimes in a number of real-time exercises during the previous year. These exercises, completed in collaboration with scientists from a number of institutions, indicate the flexibility and adaptability of HOPS, given the variety of regions and configurations.

HOPS interdisciplinary simulations during P^2S^3 were largely successful. It was found that during the early part of the bloom when nitrate is plentiful, it is primarily the effect of the local mixed layer depth on mean light intensity and the dilution of phytoplankton that dictates phytoplankton concentrations. While physical processes move the patches around horizontally, it is only when nitrate starts to become depleted that mesoscale vertical velocities contribute to patchiness.

The basin scale and synoptic scale circulation elements in the Black Sea have been reproduced in data driven simulations, and the role of forcing and topography in the evolution of the rim current has been explored.

HOPS is vertically integrated within the Harvard oceanography research group, facilitating interactions in fundamental and applied areas of research. HOPS is used for demonstration and validation of regional forecasting systems, fundamental research in ocean processes in the coastal and shelfbreak regions, a testbed for new data assimilation schemes and interdisciplinary work in biogeochemical modeling and simulations. The system has been distributed to several national and

foreign research and operational sites. On-going training and collaborations using HOPS in various regions of the world ocean are presently being pursued.

IMPACT/APPLICATIONS

Ocean Prediction Systems (OPSs) for contemporary ocean science and marine technology consist generally of: i) a set of coupled interdisciplinary models; ii) an observational network with multiple platforms and sensors; and, iii) data assimilation schemes with measurement models and error models. The nowcasts, forecasts and data driven simulation products of OPSs have important applications for: i) the efficient conduct of real-time scientific research in the intermittent ocean; ii) marine resource exploration, exploitation and management; and, iii) naval and marine operations.

TRANSITIONS

Completed and continuing research transitions are with: MIT Sea Grant; Southampton Oceanography Center; NRL Stennis; Naval Postgraduate School; SACLANT Undersea Research Centre; WHOI; SIO; Univ. of Colorado; JPL Pasadena; Old Dominion University; Institute of Marine Sciences, Turkey; U. Tokyo; CNR Ancona, Italy; Dartmouth College; University of Warwick, UK; and U. Mass. Dartmouth.

RELATED PROJECTS

This project has relationships to the National Ocean Partnership Program in the development of the scientific and technical conceptual basis of a generally applicable Littoral Ocean Observing and Predictive System (LOOPS) with Johns Hopkins University (APL), MIT - AUV Lab., MIT - Sea Grant, MIT - Ocean Engineering, Naval Underwater Warfare Center, National Marine Fisheries Service, Raytheon, Tracor Applied Science, Univ. of California - Santa Barbara, Univ. of Massachusetts Dartmouth; research towards the construction of an Advanced Fisheries Management and Information System (AFMIS) with U. Mass-Dartmouth (Prof. B. Rothschild), BIO-OPTICS research (Dr. Jeffrey Dusenberry), the Shelfbreak PRIMER and Harvard 6.1 research (Dynamics of Oceanic Motions), as well as external collaborations in conjunction with transitions.

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